OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

CHEMISTRY 2815/01

Trends and Patterns

Wednesday **29 JANUARY 2003** Afternoon 1 hour

Candidates answer on the question paper.
Additional materials:
Data Sheet for Chemistry
Scientific calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	15	
2	8	
3	10	
4	12	
TOTAL	45	

This question paper consists of 10 printed pages and 2 blank pages.

Registered Charity Number: 1066969
[Turn over

3 Iron is a typical transition element.

- Iron shows more than one oxidation state in its compounds.
- Iron and its compounds are used as catalysts.

(a) Complete the electronic configuration for an **iron(III) ion, Fe^{3+}**, and use it to explain why iron is a transition element.

Fe^{3+}: $1s^2 2s^2 2p^6$ .....

explanation .....

..... [2]

(b) State **one** use of iron or one of its compounds as a catalyst. State the name of the catalyst and the reaction catalysed.

name of catalyst .....

reaction catalysed ..... [1]

(c) Under certain conditions iron can be oxidised to form sodium ferrate, Na_2FeO_4. This is a red-purple coloured substance that has properties very similar to that of potassium manganate(VII).

(i) Analysis of a sample of sodium ferrate showed that it contains the following percentage composition by mass,

Na, 27.74%, Fe, 33.66% and O, 38.60%.

Show that these data are consistent with the formula Na_2FeO_4.

[2]

(ii) Deduce the oxidation state of iron in sodium ferrate, Na_2FeO_4.

..... [1]

(d) The half-equation for the reduction of ferrate ions, FeO_4^{2-}, in acidic conditions is shown below.

$$FeO_4^{2-} + 8H^+ + 4e^- \longrightarrow Fe^{2+} + 4H_2O$$

Acidified FeO_4^{2-}(aq) ions oxidise aqueous iodide ions, I^-, to form aqueous iodine, I_2.

(i) Construct the half-equation for the oxidation of iodide ions to form iodine.

..... [1]

(ii) Construct the ionic equation for the redox reaction that occurs between aqueous FeO_4^{2-} and aqueous I^- in the presence of H^+.

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..... [2]

(iii) Predict the colour change you would see when aqueous FeO_4^{2-} is added to an excess of aqueous I^- in the presence of H^+.

from ..... to ..... [1]

[Total: 10]

4 In this question, one mark is available for the quality of written communication.

Iron forms complex ions such as $[Fe(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{3+}$.

- Describe and explain the bonding in, and the shape of, **one** of these complex ions.
- Explain why the H—O—H bond angle in water in an isolated gaseous molecule is different from that in the complex $[Fe(H_2O)_6]^{2+}$.
- Describe, with the aid of suitable equations, how the two complex ions can be distinguished by means of a chemical test.

Answer **all** the questions.

1 **(a)** A student wished to analyse the iron(II) content of a tablet given to pregnant women. He decided to oxidise the iron(II) with acidified potassium dichromate(VI).

The standard electrode potentials for the reactions involved are given below.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O \qquad E^\ominus = +1.33\,V$$

$$Fe^{3+} + e^- \rightleftharpoons Fe^{2+} \qquad E^\ominus = +0.77\,V$$

(i) Define the term *standard electrode potential.*

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..... [3]

(ii) Explain, using the data given, why acidified dichromate(VI), $Cr_2O_7^{2-}$, is able to oxidise iron(II), Fe^{2+}.

.....

..... [1]

(iii) Construct the equation for this oxidation.

[2]

2 Brass is a copper-containing alloy which is widely used for decorative purposes.

(a) What is the other main metal present in brass?

..... [1]

(b) A sample of brass was analysed to find the percentage copper that it contained.

- 0.500 g of brass was used
- the copper in the brass was converted into Cu^{2+} ions

  $Cu \longrightarrow Cu^{2+} + 2e^-$
- the Cu^{2+} ions were reacted with I^- ions to make I_2

  $Cu^{2+} + 2I^- \longrightarrow \frac{1}{2}I_2 + CuI$
- the I_2 was titrated with thiosulphate ions, $S_2O_3^{2-}$, using starch indicator

  $I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2I^-$
- 22.3 cm^3 of 0.200 mol dm^{-3} thiosulphate were needed for the titration.

(i) Calculate the amount of thiosulphate used in the titration.

..... mol [1]

(ii) Deduce the amount of I_2 that was titrated.

..... mol [1]

(iii) Deduce the amount of copper present in the sample of brass.

..... mol [1]

(iv) Calculate the percentage of copper present in the sample of brass.

[2]

(c) A student carried out the titration but forgot to add the starch indicator.

(i) What colour change would the student see at the end point **without** starch indicator?

from ..... to ..... [2]

(ii) Why is the colour change at the end point easier to see if starch is used?

.....

..... [1]

(d) Name another common alloy of copper and give a use for this alloy.

name .....

use ..... [2]

[Total: 11]

3 **(a)** A complex ion contains one Fe^{3+} ion, four molecules of ammonia and two chloride ions.

(i) What is the formula of this complex ion? ..... [1]

(ii) This complex shows *cis-trans* isomerism. Draw diagrams to show the structures of the *cis* and *trans* isomers.

[3]

(iii) What is the co-ordination number of this complex ion?

..... [1]

(b) Describe the role of *cis*-platin as an important therapeutic drug.

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..... [2]

[Total: 7]

5 In this question, one mark will be awarded for the quality of written communication.

Cobalt is a transition element and therefore forms complex ions with different oxidation states. Many of these complex ions have characteristic colours.

By reference to suitable complex ions, describe the two most common oxidation states of cobalt. Include, where relevant, the stability and colours of the complex ions you describe.

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Quality of Written Communication [1]

[Total: 7]

Answer **all** the questions.

1 *Syngas* is a mixture of carbon monoxide and hydrogen gases, used as a feedstock for the manufacture of methanol.

A dynamic equilibrium was set up between carbon monoxide, CO, hydrogen, H_2, and methanol, CH_3OH. The equilibrium system is shown by Equilibrium 1.1 below.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \textbf{Equilibrium 1.1}$$

The equilibrium concentrations of the three components of this equilibrium are shown below.

component	CO(g)	$H_2(g)$	$CH_3OH(g)$
equilibrium concentration /mol dm^{-3}	3.1×10^{-3}	2.4×10^{-2}	2.6×10^{-5}

(a) State **two** features of a system that is in *dynamic equilibrium.*

.....

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.....[2]

(b) **(i)** Write the expression for K_c for this equilibrium system.

[2]

(ii) Calculate the numerical value of K_c for this equilibrium.

[2]

(c) The pressure was increased whilst keeping the temperature constant. The system was left to reach equilibrium. The equilibrium position of Equilibrium 1.1 shifted to the right.

(i) Explain why the equilibrium moved to the right.

.....

.....[2]

(ii) What is the effect, if any, on K_c?

.....[1]

(iii) State and explain the effect on the rates of the forward and reverse reactions

- when the pressure was first changed
- when the system reached equilibrium.

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.....[4]

(d) The temperature was increased whilst keeping the pressure constant. The system was left to reach equilibrium. The value of K_c for Equilibrium 1.1 decreased.

(i) Explain what happens to the equilibrium position of Equilibrium 1.1.

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.....[2]

(ii) Deduce the sign of the enthalpy change for the forward reaction shown in Equilibrium 1.1. Explain your reasoning.

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.....[1]

(iii) Explain how the partial pressure of $CH_3OH(g)$ would change as the system moves towards equilibrium.

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.....[1]

[Total: 17]

2 Nitrous oxide, N_2O, is a colourless gas with a mild, pleasing odour and sweet taste. It is widely used as a propellant in aerosol cans of whipped cream.

(a) Nitrous oxide is formed when ammonium nitrate, NH_4NO_3, is gently heated.

$$NH_4NO_3(s) \longrightarrow N_2O(g) + 2H_2O(l)$$

(i) What mass of N_2O is formed by heating 100 g of NH_4NO_3?

[3]

(ii) What happens to the oxidation number of each nitrogen from NH_4NO_3 in this reaction?

.....

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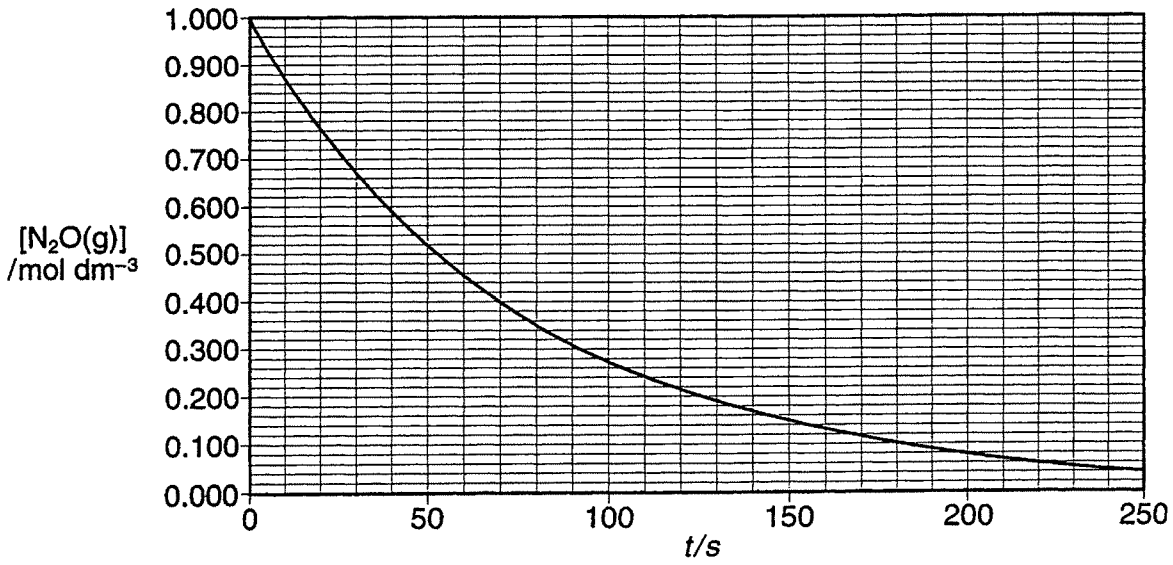
.....[2]

(b) When heated strongly, nitrous oxide decomposes into its elements.

$$2N_2O(g) \longrightarrow 2N_2(g) + O_2(g)$$

This reaction is first order with respect to N_2O.

The graph below shows how nitrous oxide decomposes with time at constant temperature.



(i) Explain how the graph confirms that this reaction is first order with respect to N_2O.

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.....[3]

(ii) Write the expression for the rate equation of this reaction.

[1]

(iii) Use the graph to work out the rate of reaction, in mol dm^{-3} s^{-1}, at 70 seconds. Show clearly your working on the graph.

rate = ...mol dm^{-3} s^{-1} [2]

(iv) Calculate the rate constant for this reaction. State the units.

k = ... units ..... [2]

(v) What evidence is there that the mechanism of this reaction takes place in more than a single step?

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.....[2]

(c) N_2O is occasionally injected into the engines of racing cars to give more power and exceptional acceleration. The N_2O decomposes exothermically to N_2 and O_2.

Suggest **two** reasons why this reaction provides an extra boost to the engine.

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.....[2]

[Total: 17]

3 In this question, one mark is available for the quality of written communication.

(a) Describe what is meant by the following terms used in acid-base chemistry.

- The Bronsted-Lowry theory of acids and bases.
- Conjugate acid-base pairs.
- Dilute and weak acids.

Illustrate your answer by choosing suitable examples of acids and bases. Write equations where appropriate.

....[7]

Quality of Written Communication [1]

For Examiner's Use

(b) The acid dissociation constant K_a of hydrocyanic acid, HCN, is 4.9×10^{-10} mol dm^{-3}.

(i) Write an expression for the acid dissociation constant of HCN.

[1]

(ii) Calculate the pH of a 0.010 mol dm^{-3} solution of hydrocyanic acid.

[3]

[Total: 12]

4 Organic acids occur widely in nature.

(a) Butanoic acid, $CH_3(CH_2)_2COOH$, is a straight-chain organic acid, largely responsible for the odour of rancid butter.

Caprylic acid is another straight-chain organic acid. It is produced in the body in small amounts as an antifungal agent in human sweat.

(i) Some caprylic acid was isolated from human sweat and analysed. The sample of caprylic acid had the percentage composition by mass:

C, 66.7%; H, 11.1%; O, 22.2%. $M_r = 144$.

Calculate the molecular formula of caprylic acid and suggest its structural formula.

[4]

(ii) Tracker dogs are trained to follow odours such as the characteristic blend of organic acids in the sweat from a person's feet. A dog is able to detect extremely small quantities of these acids.

Sweat containing equal amounts of butanoic and caprylic acids produces more butanoic acid vapour than caprylic acid vapour.

Suggest a reason for this. Explain your answer.

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.....[2]

(b) Compound **A** is a straight-chain organic acid. A chemist analysed a sample of acid **A** by the procedure below.

The chemist first prepared a 250 cm^3 solution of **A** by dissolving 10.8 g of **A** in water.

In a titration, 25.00 cm^3 0.500 mol dm^{-3} NaOH were neutralised by exactly 21.40 cm^3 of solution **A**.

- Calculate the pH of the NaOH(aq) used in the titration. $K_w = 1.00 \times 10^{-14}$ $mol^2 dm^{-6}$.
- Use the results to calculate the molar mass of acid A and suggest its identity.

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[Total: 14]